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FOREST SERVICE

LAKE STATES FOREST EXPERIMENT STATION

ST. PAUL, MINN.

REPORT TO THE ADVISORY COMMITTEE

FOR 1929

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EXPERIMENT STATION

Advisory Committee

Lake States Forest Experiment Station

Michigan

Appointments expire in 1930

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Dean S. T. Dana	University of Michigan

Appointment expires in 1931

George R. Hogarth	Department of Conservation
P. S. Lovejoy	Department of Conservation

Appointment expires in 1935

John M. Bush	Upper Peninsula Development Bureau

Minnesota

Appointment expires in 1930

Dean W. C. Coffey	University of Minnesota

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Grover M. Conzet	Conservation Commission

Appointment expires in 1933

H. C. Hornby	Northern Pine Manufacturers Association

Appointments expire in 1935

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C. L. Cecil	Pulp and paper industry

Wisconsin

Appointment expires in 1930

Dean H. L. Russell	University of Wisconsin

Appointments expire in 1931

Wm. J. P. Aberg	Izaak Walton League
W. A. Holt	Hemlock & Hardwood Manufacturers Association

Appointment expires in 1933

Paul D. Kelleter	Department of Conservation

Appointment expires in 1935

James B. Nash	Pulp and paper industry

Illinois

Appointment expires in 1933

Dr. H. C. Cowles	University of Chicago

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ORGANIZATION
OF THE
LAKE STATES FOREST EXPERIMENT STATION

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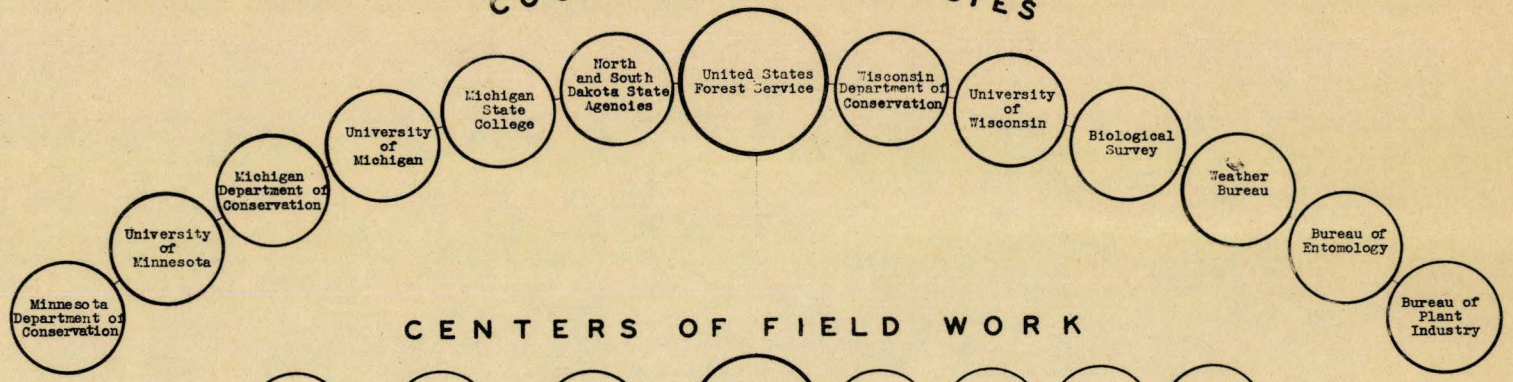

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LAKE STATES FOREST EXPERIMENT STATION*

REPORT TO THE ADVISORY COMMITTEE

FOR 1929

ORGANIZATION

During the last calendar year the Federal appropriation for the Experiment Station increased from $36,657.97 to $56,163.89. This, together with the money obtained from state cooperation, raised the total budget to $63,097.93 and resulted in a corresponding enlargement in the scope of the work and in the personnel of the Station. The permanent staff was increased from eleven to seventeen since the last report was issud. During the past field season, the personnel, including the temporary assistants, numbered close to 30 people. All this necessitated some changes in the organization.

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*Maintained by the U. S. Department of Agriculture at Saint Paul, Minnesota, in cooperation with the University of Minnesota.

PROGRESS TO CATE AND PLANS FOR 1930

Forest Fire Studies

The outstanding accomplishments of the year in the way of fire studies were:

1. The publication of the results of the fire hazard study carried on in 1928 in cooperation with the College of Agriculture of the University of Wisconsin and the Wisconsin Department of Conservation. This report, entitled "Forest Fire Hazard as Affected by Weather Conditions, Forest Type and Density of Cover," was issued by the University of Wisconsin as Agricultural Experiment Station Research Bulletin No. 91, under date of April, 1929.

2. The completion of the analysis of Michigan forest fire statistics and the preparation of a report for State publication entitled "Forest Fires in Michigan."

3. The preparation of a Technical Note (No. 21) entitled "How Long Does Hardwood Slash Remain a Fire Menace?" based on observations of old cuttings throughout northern Wisconsin and Michigan made during the past four years.

4. The consummation of a cooperative agreement with the Michigan Conservation Commission for the establishment and joint operation of a Forest Fire Experiment Station in lower Michigan.

The preparation of the report, "Forest Fires in Michigan" completes the analysis of Lake States forest fire statistics contemplated for the present. Later on a similar study should be made for Wisconsin and eventually the Minnesota and Michigan studies should be brought up to date. Nothing further along this line, however, is planned for 1930.

While the publication of the fire hazard bulletin completed the work on this project in Wisconsin, similar observations have been continued at the Upper Michigan branch station in northern hardwoods to check the results secured in the former state.

Further work is also being done at the Upper Michigan Branch station on the decay of slash under various degrees of cutting and methods of slash disposal. This promises valuable results in the course of the next few years.

The establishment of a Forest Fire Experiment Station in lower Michigan marks the beginning of a new era in forest fire investigations in the Lake States by affording an opportunity for intensive and concentrated study of the technical problems of forest fire protection. Under the terms of the cooperative agreement, the State will furnish the land

and improvements while the Lake States Station will provide the office and technical equipment needed. A great deal has already been accomplished toward getting the investigations under way. About 3,800 acres of wild land in Crawford and Roscommon counties have been set aside, surveyed and mapped; exterior fire lines have been constructed; a headquarters' building providing office, laboratory, and living quarters, and ample garage and storage space has been built; office furniture and field and laboratory equipment has been ordered; and a program of investigations has been prepared. In short, the stage is all set to begin active operations with the opening of the spring fire season.

The program of investigations proposed embraces the following projects:

1. Fire weather
2. Fire fuels
3. Fire behavior
4. Fire damage
5. The use of chemicals in fire suppression and control
6. Firebreaks and fire lines
7. Fire-fighting methods and equipment

Three of these projects (2, 4, and 5) are already on the Lake States Station program, though to date work has been done only on Number 2. Number 1 was formerly a station project, but was dropped in 1928 in order to concentrate on Number 2 and the analysis of forest-fire statistics now completed. Numbers 3, 6, and 7 are new projects. The last two will be carried on by the Station with the cooperation of the State of Michigan. While this list covers a wide field, the projects are closely related and can be carried on to the best advantage simultaneously since much of the work done can be made to contribute to several projects.

Briefly, it is proposed: to keep a complete record of current weather conditions throughout the fire season, approximately April 1 to November 15; to record currently the fire hazard prevailing locally and in adjoining protection districts; to check the applicability of the general fire weather forecasts issued by the Weather Bureau; to make daily inflammability tests and moisture content determinations of the prevailing forest fire fuels both in the open and in the forest; to establish permanent sample plots for the study of fire damage, plant succession, the accumulation and decomposition of forest litter, and the rate of deterioration of slash; to study the behavior of experimental and going fires at various seasons and under various conditions; and, in cooperation with the State, to study the effectiveness of various types of firebreaks and fire lines, the methods and costs of their construction and maintenance, and to study the effectiveness and efficiency of various fire-fighting methods and equipment.

While most of the projects proposed will take several seasons to complete, concrete results should be obtained in several directions as the result of one season's work, particularly in the testing of equipment

and use of chemicals. Definite results will be worked up currently and issued as technical notes, full reports following as projects are completed or reach a stage where the results will justify publication.

Management of Northern Hardwood Forests

The results of the investigations regarding the advantages of partial or selective cutting over clean cutting, conducted during the field seasons of 1925, 1926, and 1928, have been published during the last year by the Wisconsin Agricultural Experiment Station as Research Bulletin 88, "How Fast Do Northern Hardwoods Grow?", and by the United States Department of Agriculture as Technical Bulletin 164, "Selective Logging in the Northern Hardwoods of the Lake States."

This work has stimulated the interest of private owners in handling their timber lands on a somewhat better basis. Probably between 100,000 and 125,000 acres of northern hardwood land are now on a partial cutting basis, with some other timber owners half committed to such practice. Selective cutting has become a subject for discussion at many of the meetings of the lumbermen. As its advantages become more evident, this method of managing the forest should find great use among the owners of northern hardwoods. It is felt that no further extensive studies of the kind that were conducted over wide areas in Wisconsin and the Upper Peninsula of Michigan are needed. Future work should be confined to more intensive localized studies of tracts cut selectively. Most of the work of this character will be concentrated at the Upper Peninsula branch station.

During the last year 32 acres were cut over on the Experimental Forest near Dukes using a modification of the previous methods of cutting employed on that forest. On the six previous cuttings each area cut over was more or less uniformly treated, and the trees removed were uniformly distributed. In last year's cutting, although the volume removed per acre was about the same as in previous cuttings, the distribution of the trees left was different. By this method small areas up to half an acre in size were cut clean; other areas were cut over very lightly. The object is to provide more light, and in this way encourage such light-demanding species as yellow birch which reproduces well in openings but not under the shade of older trees. By means of these cuttings, each of which is represented by permanent sample plots remeasured at regular intervals, the advantages and disadvantages of different methods of cutting will be clearly and accurately demonstrated.

In order to place the remaining old forest on an experimental basis at an early date, the future cuttings will be on a somewhat larger scale than they have been hitherto. This will provide a larger number of experimental cuttings upon which observations as to the effect of different methods of cutting can be made.

As fully important as the study of methods of handling old timber are the experiments made to convert cut-over land into a productive con-

dition. On the Station's half-section of cut-over land near Dukes, various cultural operations will be used. Among these are the thinning of over-stocked stands, the removal of remnants of the old stand which may be hampering the advance growth, and the planting of irregularly-stocked areas, all in an attempt to bring the whole stand to a uniform growing condition. Seven acres have already been so handled with the working plan calling for the additional treatment of 10 to 20 acres each year.

A thorough classification of the experimental forest was made upon the basis of the different soil types, and future operations will be correlated with the quality and productivity of the soil. Definite relationships have been found between height and diameter growth, the number of trees to the acre, and the abundance of natural reproduction, on the one hand, and the character and quality of the soil on the other. The soils, the stands, and the experiments conducted on the forest are described in detail in a pamphlet now in preparation. A map was also prepared correlating the various soil types with the stands as they exist on the tract.

Management of Pine Forests

Eight new permanent sample plots were established on the Chippewa and Superior National Forests during the last year, bringing the total number of plots devoted to different phases of cutting, thinning, and natural reproduction in jack, Norway, and white pine forests up to twenty-eight.

Although the remeasurement of the plots is not due for several years, the results of the count of the young growth on the cut-over areas are becoming somewhat apparent. On the Chippewa plots given over to determining the best method of cutting in jack pine with the object of increasing the reproduction of Norway pine, the results so far observed are somewhat disappointing. While the amount of Norway pine reproduction since cutting is increasing but very slightly, the number of jack pine is increasing markedly -- just the opposite of what was expected.

In the case of the plots devoted to the conversion of Norway pine to white pine on the Chippewa National Forest, it appears that the original cuttings were not heavy enough. The number of white pine seedlings present remains practically unchanged, but their growth has been almost negligible. A second cutting is planned for the coming year which, it is hoped, will release the suppressed reproduction.

The jack pine cutting plots on the Superior National Forest show a considerable increase in the amount of reproduction present (particularly that of jack pine which was entirely lacking at the time of cutting), but it is still inadequate. As is to be expected, the greatest number of jack pine seedlings has come in on that plot most heavily cut. No consistent differences can yet be seen between the amount of reproduction on the portion of the plots where the slash was burned and where it was lopped.

Additional investigations of the best handling of pine forests will be undertaken on the Superior National Forest during the next few years. The large timber sales now under way on this Forest create new problems. With the cuttings in progress, there should be an opportunity to try out different methods of marking as a means of improving the existing stands.

In Wisconsin the area of cut-over land listed under her forest tax law, is already very large and will increase still further. There is urgent need for information concerning growth on cut-over pine lands, figures similar to those already available for cut-over hardwood lands. As a guide for predicting growth on the pine lands, the Station, to fill this need, is planning to undertake an extensive survey this summer. This study, which will be carried on in cooperation with the University of Wisconsin and the Wisconsin Conservation Commission, will be similar in scope to that made for the hardwood lands and resulting in the publication, "How Fast Do Northern Hardwoods Grow."

Management of Swamp Forests

During the last few years the problem of improving the growth in swamps by means of drainage has received considerable attention. Several bulletins and a number of articles have been published by the Station dealing with the results of these investigations. Aside from maintaining and remeasuring the areas already under controlled drainage, both on the Chippewa National Forest and in the Upper Peninsula of Michigan, no new work is being contemplated.

The most outstanding feature observed in connection with the Station's swamp drainage experiments during the year was the depth to which the water level fell in the ditched swamp on the Chippewa National Forest. In late August a new low level of 3.2 feet below the surface was reached. Although this may have largely been due to the very dry season, there is no doubt but that the drainage ditches had much to do with it. Any effect that this lowering of the water level has upon the growth of the trees will be shown by the remeasurement of the plot in 1932.

In the drained swamp at the Experimental Forest near Marquette, several trees were found to be badly infected with dwarf mistletoe (Razoumofskya pusilla), and several of the trees have actually been killed by it.

In order to assist in evaluating the growth possible on cut-over swamp land registered under the forest tax law, the Station will undertake a study of the growth taking place in swamp forests after cutting in Wisconsin. The project will be carried on with the cooperation of the Wisconsin Conservation Commission and the University of Wisconsin and should answer the question, "How fast do cut-over swamp forests grow?"

Conversion of Inferior Stands into More Valuable Forests

The largest area in need of conversion in the Lake States is now occupied by aspen -- some 21,000,000 acres. Twenty-nine million cords in present stands over 3 inches in diameter with the prospect of much larger volumes in the next twenty to forty years as young stands reach merchantable size, means a great excess over the annual use of not over 250,000 cords. This excess supply together with the fact that aspen rots badly by the time it is 70 years old, emphasizes the need of its conversion to other more valuable species. For anyone who can use or sell aspen, returns of four or five per cent on investment and costs may be expected in holding aspen until it is 50 years old. Information on growth, management, and conversion has been published by the University of Minnesota Agricultural Experiment Station as Technical Bulletin No. 60, "Forest Possibilities of Aspen Lands in the Lake States." Another publication on the availability, properties, and utilization of aspen is being prepared by the Station in cooperation with the Minnesota Forest School and the Forest Products Laboratory.

Conversion of aspen stands to pine or spruce by underplanting has only started, and the losses in plantations over 5 years old usually exceed 50 per cent. Seed spots of white pine and white spruce have given only 1 to 22 per cent establishment both with and without cutting of the aspen overstory on the Chippewa National Forest, except where they were protected by screens from rodents. Natural reproduction of white pine increases after the seed years and decreases in the intervening periods by about the same amount. Recent experimental plantings of white pine under aspen in northern Michigan have only a 52 per cent survival after 2 years. On the Superior National Forest at the end of the second season, 68 per cent of the white pine and 77 per cent of the white spruce planted under aspen were still living.

Much planting of white pine has been done under irregular stands of scrub oak on many of the State Forests in Michigan. Results have, so far, been poor due to the suppression of the planted stock by the oaks. Experiments in freeing the pine from overhead competition are now under way in conjunction with the Michigan School of Forestry and Conservation. The entire oak stand was removed on some plots, while on others the canopy was thinned to various degrees of density.

Existing experiments will be continued, and new plots started to determine under what conditions underplanting may succeed and whether or not protection and weeding are essential.

A new set of experiments will attempt to determine the temperature, light, moisture, and other conditions necessary for the establishment and early growth of pines and spruce under aspen and jack pine. Some of the conifers will be grown under different densities of artificial shades in the nursery to determine to what extent the young trees may be shaded

without seriously interfering with their growth. Planted seedlings and sown seed will be used under different densities of aspen and jack pine to compare the resulting growth with that of the seedlings under the nursery shades. By measuring sunlight, soil moisture, air, and soil temperatures and correlating these with the degree of cutting, the optimum crown density for reproduction and practical methods of conversion may possibly be worked out.

Reforestation Studies

Seed-testing Estab.ishment

The most important Station development in reforestation studies during the last year has unquestionably been the installation of equipment which will furnish satisfactory conditions for seed testing at University Farm. The establishment of the seed control station was made possible through the usual courtesy of the College of Agriculture of the University of Minnesota which provided not only space in the Old Dairy Building for the laboratory but contributed generously of its own funds for remodeling the room for this purpose. This makes it now possible for the Station to give seed-testing service to the various forest agencies of the region and insures the same conditions year after year for the tests that are necessarily made in connection with breeding studies, seed-storage experiments, and the like. Since the new set-up was completed in the fall of 1929, some 280 germination tests have been run, of which about 50 have been of "commercial" seed samples, and the remainder involved in various experiments.

The equipment consists primarily of two large germination rooms equipped with both heating and cooling apparatus so that the temperature may be closely controlled. In addition, there is a small chamber for seed storage at 50°F, and a larger room where germination or pre-germination treatment may be given at a constant temperature of 60°. Tables, sand-flats, fans, and temperature-recording apparatus complete the outfit.

Tests made since the installation of the equipment have shown that for actual germination tests a reasonably constant temperature in the sand flats of about 70° can hardly be excelled. This has been proven for well-ripened Norway pine seed by an exhaustive series of tests at various temperatures, both with and without daily oscillations. There are some "obstinate" lots of unripened Norway pine seed which undoubtedly have to be dealt with differently, and white pine (perhaps also the spruces) rarely responds to a simple treatment at 70°. It is, however, believed that this difficulty is to be overcome by pre-germination treatments rather than during the germination process itself. It has, for example, been fully demonstrated that the readiness of white pine seed to germinate can be greatly altered by a 15-day treatment at 50° F, and such treatment can be made a prerequisite of every germination test of this

species, actually shortening the time required to bring out the germinable seeds. It is expected that something similar will be found effective in the case of white spruce, and perhaps other species.

White Pine Pre-treatment

Spring sowing of white pine because of its delayed germination often results in scattered or uneven-aged stands of this species both as a means of bringing out its full potentialities within a reasonable length of time, and as a means of insuring a better and more prompt germination in nurseries. A comprehensive study of white pine seed has been under way since the early winter of 1928-1929. The effect of heat and cold, of water, acids, and alkalies, have all been investigated with the result that it has been shown that the unwillingness of most (if not all) white pine seed to germinate quickly when sown under conditions which are ideal for other species is not at all a matter of "resistance to moisture," seed-coat impermeability, or failure to absorb moisture, but is due to the necessity for a low-temperature cycle to prepare the seed for germination. While all of the above-mentioned treatments have affected some few of the seeds of the lots to which they were applied, no drastic change nor satisfactory germination was obtained until white pine seed was subjected to cold and moisture for periods of 15 and 30 days. These treatments were applied in a sufficient number of ways to demonstrate that only a small quantity of moisture is necessary, and that the remarkable effect is due almost wholly to chemical changes which take place in the seed at low temperatures.

It is thus possible, by mixing the seed with slightly moist sand or sawdust and storing in a cold cellar for 2 to 4 weeks before sowing time, to obtain from spring sowing all of the advantages of fall sowing, and in some instances, at least, without the danger of rodent losses. Separation of the seed for sowing is accomplished by the use of a screen coarse enough to pass the previously sifted sand or sawdust, but not the seed. Provided it is not prolonged, the mixture may be somewhat dried before this separation is attempted.

This study may be considered essentially complete. There should be a further attempt made to clarify the nature of the changes which occur when the seed is subjected to cold and also the effect of this treatment on old seed. A full report will be prepared for the Journal of Agricultural Research on the various tests which have been made. A thorough biochemical investigation of the changes in the seed has been suggested, in which the Station would take the part of preparing the seed material in various ways and of conducting germination tests to determine its physiological status at various times, while analyses of carbohydrate and protein contents of the seeds would be made by a chemist.

Seed-storage Tests

As has already been stated, cold has some effect on white pine seed which makes it more ready to germinate. This appears to be the case even in dry storage, as shown by the germination of the white pine seed of the 1928 crop stored one year. When this seed was fresh, germination as high as 40 per cent was obtainable from only a few samples. A few months later some samples which had been stratified until April at low temperature and about 4 per cent sand moisture, germinated as high as 60 per cent, but only after a very long period. In contrast, the seed stored dry for a year when sown in December, 1929, gave an average germination of 58 per cent at the end of 72 days, most of this occurring in much less time. Of the various conditions, seed stored in a deep cellar gave the highest germination an average of 64.4 per cent, with a sample dried at 30 per cent atmospheric humidity yielding the highest single result, 68.6 per cent. Under all conditions of storage, this degree of moistness proved better than either higher or lower moisture. The seed stored in a warehouse (10° to 100° annual range of temperature) suffered the most, especially in the unsealed bottles where considerable drying occurred. Storage at 32° F. constant temperature was only slightly inferior to that in the cellar. (Technical Note 23 and "Note" in the Journal of Forestry.)

It is possible that these conditions may not represent the best conditions for long-continued storage, since they may have had more effect in making the seed ready for germination at the end of a single year than in actually preserving its vitality. While this does not seem probable, only repeated annual tests can tell the full story.

An additional storage experiment with somewhat better white pine seed (1929 crop) has been started, including, in addition to the three conditions already employed, a steady temperature of about 50° F. This seed went into storage dried at atmospheric humidities of 20 per cent, 35 per cent, and 50 per cent, the last being a little higher than heretofore employed since the seed contained greater moisture when treated.

The results of the Norway pine seed storage test, as obtained in May, 1929, at the end of one year, were essentially in agreement with those described for white pine, although it is probable that the ideal moisture condition for Norway pine seed is a little lower than that for seed of the latter species. (Technical Note No. 15). The second test on this seed will be run in April, 1930, and may be expected to show more marked differences. Due to certain limitations of this storage experiment, a new one was started during the winter of 1929-1930 with a larger number of seed samples of better original quality, with the expectation of keeping up the germination tests on the same seed for about 20 years.

As soon as good seed of white spruce is obtainable, a storage test on this species will also be started. Other species may be brought into the series from time to time. Some species, however, seem to present almost no problem of "keeping." For example, a sample of Scotch pine

seed, collected in 1925 and subjected to a great deal of handling and to all imaginable conditions of moisture and temperature encountered in different climates, promptly gave 67.5 per cent germination when tested recently. It is believed that jack pine seed has similar hardy qualities.

Nursery and Planting Studies on the Huron National Forest

While studies to determine the best class of stock and the best methods for planting on the sand plains of Michigan have been under way for many years, being formerly directed by Research in the Rocky Mountain District, new developments and changing conditions seem to require a thorough going-over of technical considerations which affect the plantings. It is, therefore, probable that a new series of experiments will be initiated on that Forest during the next year or two, under plans made jointly by the Experiment Station and the administrative force, and to be largely handled by the latter. These should include, among other things, more comprehensive tests of species, mixtures, and plantation-spacing than have yet been made. They should give more attention to jack pine which already has a desirable market. They should attempt to develop local sources of seed supply for the Norway pine and other species that are being used, instead of using seed from northern Minnesota with its more rigorous climate.

Meanwhile the Station is making an examination of the past weather records of the region to determine whether seasons such as 1927 and 1929, which caused severe losses in young plantations, are likely to recur frequently.

Prairie Planting

Interest has recently been revived in the planting of trees by farmers in the plains regions of southwestern Minnesota and the Dakotas. The fate of the older plantations in this region has been a subject long deserving of study, since it is in many ways not encouraging to the newer generation of farmers. In making a survey of such older plantations, especial attention will be given to the possible effect of "tight soils" on root development and abnormally early senility, in the hope that if this is found to be a factor it can be overcome in preparing the ground for new plantations.

Naturally, the windbreak aspect rather than the timber-growing aspect of prairie planting should be given emphasis. There is, in addition, the strong probability of the development of a federal planting project in northern North Dakota comparable to the Nebraska sandhill planting. All of this is contingent upon appropriations now being considered by Congress.

Tree Breeding

Norway Pine

The possible improvement of this species through "selection" methods commands the greatest attention because of its large-scale use in going reforestation projects. In May, 1929, seeds of 41 lots of Norway pine representing different localities in the natural range of this species, and to some extent individual trees in the same localities, were sown in the Cass Lake nursery with the expectation of growing 500 trees of each lot for later planting in at least three different parts of the range. Germination was variable and from 100 to 600 trees of individual lots were obtained, with an average of about 300. Weights of seedlings at the end of 1929 showed that there is a regular g adation in size from north to south, the forms which grow in the coolest portions of the range regularly producing the smallest seedlings. (Technical Note 19)

Because of the variation in stocking of the rows, it is planned to transplant these trees in the spring of 1930 to re-space them for even growth instead of growing them two years in the seed beds. At the time of transplanting, observations will be made on the over-wintering losses in the hope of obtaining data on the relative hardiness of seedlings from different parts of the range.

With relation to this characteristic which may possibly be detected without waiting for the results of field plantings, 28 of the same seed lots, pot-grown over the summer, were tested for hardiness at University Farm in December, 1929. The critical temperature for this particular stock having been found by previous trials to be about 20° F, these 28 lots were all subjected to such a temperature after a week of cooling at about 32°. The result was that 51 per cent of the seedlings whose seed was collected in the northern half of the range survived such drastic freezing, while only 10 per cent from the southerly part of the range survived. Stock from Michigan and eastward proved much less hardy than the western stock, the latter being accustomed to much lower winter temperatures, while the most hardy stock appears to come quite generally from the southern shore of Lake Superior, in Wisconsin and Michigan. (Technical Note 22)

Tests of this sort may well be repeated until the range of the species can be quite definitely mapped for hardiness. The seedlings, however, should be grown under more natural temperature conditions in order that they may have a normal opportunity to "ripen" before being severely frozen.

While a few additional lots of Norway pine seed were collected in 1929, further nursery sowings will not be attempted until the collections from all parts of the range can be completed and assembled. It is hoped that the season of 1930 will permit this, so that all of the stock of this species may be put into field plantations with an age variation of only two years.

Scotch Pine

While this species has not proven generally desirable in the Lake States, the extent of its use and misuse through seed of improper origin, justifies an attempt to find the strain most suitable for our conditions. Accordingly, a varied assortment of seed from planted specimens in this region and from sources as far away as Norway, Esthonia, and Manchuria were sown at Cass Lake in 1929, the treatment being the same as that described for Norway pine. A total of 16 lots was available. These seedlings will also be transplanted in 1930. An interesting point was brought out by weighing samples of the seedlings at the end of the 1929 season. It was found that seedlings of the so-called "Riga variety," a valuable and popular form in Europe, were among the largest of all, in direct contradiction to previous reports on this variety from some Forest Service nurseries. Both the Ontario Forestry Branch and the Nekoosa-Edwards Paper Company are sufficiently interested in this species to desire to grow stock of as many forms as the Station can supply them with.

Norway Spruce

Much the same situation exists with respect to Norway spruce, long planted in the Lake States as has been mentioned for Scotch pine, except that there appears to be no authentic information as to the origin of seed of successful Norway spruce plantations. There can be no doubt that Norway spruce would have advantages over the native white spruce for pulpwood plantations, because of the much more rapid growth of the former in youth. Two important forestry agencies are contemplating the extensive use of Norway spruce in northern Wisconsin. It is known, however, that many of the forms of this species do not prove hardy under our most severe conditions, almost annual injury to the tips occurring in some instances, at least while young. It remains to be seen, then, whether or not the characteristic of rapid growth can be retained when a truly hardy and satisfactory form is found. The Station expects to go into this question through the collection of seed from collaborators abroad and from some of the most satisfactory of the older plantations in the region. There will probably be no nursery sowing until 1931.

White Pine

The valued qualities of white pine, together with the fact that it is a tree much less resistant to disease, insects, and other injurious agents than Norway pine and as a result may be expected to show more important variations in heritable characters than the latter, are reasons for taking up the genetic study of this species on an extensive scale. This has been delayed onMy until a method of procedure could be worked out by the Norway pine study, and until more was known about handling the seed of white pine.

It is, therefore, expected to begin extensive seed collections of white pine with the 1930 crop. The collaboration of several eastern collectors has already been offered for this study.

Sugar Maple - "Bird's-eye"

There has been practically no activity in this project during 1929, while awaiting the preliminary work that has been done to determine whether an environmental cause for the formation of bird's-eye in maple can be discovered. Pillow at the Madison Laboratory has continued some microscopic work along this line. It has not been possible, so far, to discover a satisfactory method for grafting scions of bird's-eye trees on root stocks through the work done at Madison last year. The only stock now under development which may throw any light on the subject is a lot of about 200 forest-pulled seedlings of "likely parentage" growing in the nursery at the Upper Peninsula branch station. These will be planted in the arboretum there in 1930.

It is proposed, as a means of settling one phase of the question, to make a careful study of the suppression history of bird's-eye and normal maples to a sufficient extent to determine whether the "hunch" has any foundation, namely, that the bird's-eye characteristic originates during and possibly as a result of long suppression under natural forest conditions. Instead of searching the woods for such trees, it is proposed to analyze butt-logs in the yards of the two largest handlers of bird's-eye maple in northeastern Wisconsin.

Volume, Growth, and Yield Studies

Yield of Second-Growth White Pine

The growth, yield, and commercial possibilities of second-growth white pine in Wisconsin were the object of a cooperative study between the Station and the Wisconsin Agricultural Experiment Station during the last year. Measurements taken on some 130 sample plots located throughout the state serve as a basis for the yield tables constructed. As the area of natural second-growth white pine in the state is limited, these yields are chiefly interesting as indicating the results to be expected from plantations on the large areas of cut-over land suitable for growing this species. Well-stocked stands on average sites were found to yield 31,000 board feet per acre in 70 years in trees 8 inches in diameter and over. At present stumpage prices white pine, if only 75 per cent stocked, will earn 4 or 5 per cent interest on investment and costs.

The manuscript has now been completed and will be published as a bulletin of the Wisconsin Agricultural Experiment Station during this summer. With the publication of this bulletin, the project will be completed.

Volume Tables for Second-Growth Norway Pine and White Pine in the Lake States

Volume tables, based on the measurements of 500 trees, have been prepared for white pine in total cubic feet and in board feet, the latter

by the International (1/8-inch kerf) and Scribner Decimal C rules. They will be published in the bulletin on yields of second-growth white pine in Wisconsin. Existing volume measurements for second-growth Norway pine were canvassed, but it appears that further data will be necessary for the preparation of such tables. These needed additional measurements will be obtained incidentally to other work as opportunity offers.

Fundamental Laws Underlying Development of Stands

The relation of volume to height in even-aged fully-stocked stands and the relation of diameter distribution and number of trees per acre to average diameter were further tested and confirmed in the preparation of the second-growth white pine yield tables.

These relations offer promising prospects of a simplified method of using yield tables for the prediction of growth in understocked stands. The solution of this problem in a region where probably 90 per cent of the forest area is less than fully stocked has an immediate local practical importance and also a much broader national utility.

Forest Influences: (Streamflow, Erosion, Windbreaks)

Erosion in Southwestern Wisconsin

In cooperation with the Wisconsin Agricultural Experiment Station the Lake States Station carried on an erosion study in three counties in the non-glaciated section of southwestern Wisconsin during last summer, to be supplemented by additional observations made during the snow-melting period of 1930. This study sought to determine the actual extent of erosion in areas where it appears most serious, the extent of its contribution to stream-silting, and the sources of the water which causes it and was made on farms characterized by timbered ridges, by pastures on upper slopes, and by fields on the lower slopes and stream terraces. While the data have not all been assembled, it is evident that the rapid and extensive movement of deep terrace soils on limited areas, in addition to causing damage to the farms, are creating local and national problems in the silting of the Mississippi River as well as some of its tributaries. It is this phase of the matter which justifies public interference, even, perhaps, to the extent of withdrawing land from agricultural use in the areas affecting most critically the Mississippi flood and silting problem.

As to the importance of forests in holding back the water which falls on the steeper slopes, the study made at a number of temporary stations leaves not the slightest doubt. The run-off from even the most violent of summer rains proves to be insignificant in the case of forests with deep litter. Next in retentive capacity probably come hayfields, especially those which are mowed only once annually and hence accumulate a mat of dead grass. Hard-packed blue grass pastures are the worst offenders, yielding quick run-off from every rain of consequence, although fields of small grain are nearly as bad. The former erode very little,

but may seriously affect fields lying below them. Cornfields kept in good tilth until midsummer do not yield water so readily, although when they become saturated, erosion is naturally very rapid. Heavily-pastured open forests are found to have little more value than open pastures. Roads are, in many cases, the source of water for very serious erosion, as a result of bank cutting and insufficient ditch protection and carry off.

It can hardly be expected that forested areas will perform their protective function as well when large volumes of water are being released from melting snow in the spring. The extent to which they fail will, naturally, depend on the moistness of the soil when it froze in the fall and the extent to which percolation channels are available in the spring, either through the failure to freeze solidly or through early thawing. Nevertheless, the extent to which even hardwood cover slows up snow melting must give the forested area some advantage, even if all of the water must run off.

It would seem that very little more time should be spent on this study until the Departmental Committee on Erosion is ready to establish a station in the region for more intensive work. There is a large opportunity in this section for applying the knowledge already available through the Extension Division of the Wisconsin, Iowa, and Minnesota Agricultural Experiment Stations. The Highway Departments of the various states should also be educated to their responsibility for the construction of roadways and drainage ditches in such a manner that they will not further aggravate the situation. The opportunity for erosion control by the Federal Government in this region is probably through the acquisition of key lands near the Mississippi River, and through the River Commission which should be led to expend some of its engineering effort on the side streams which bring enormous loads of silt into the river from the bluff lands. This is one way in which the "river problem" can be treated at its sources.

The permanent erosion station in this region, in addition to studying agricultural methods for preventing erosion and engineering methods for its control through actual run-off measurements on a number of small areas within a typical farm, should also have a "forestry department" which will study the whole problem of the economic management of hardwood forests. It must be realized that it is one thing to recommend the growing of timber by the farmer, and another to convince him that it is profitable to retain the ridges and steep slopes of his farm purely for timber-growing purposes. It is not sufficient, therefore, to treat a forest area solely with a view to the protection of something more valuable. It must be shown how the forest can pay dividends.

Bad-Lands Erosion

Since, so far as known, no one has ever attempted a critical study of the erosion and vegetation problems of the Dakota Bad-Lands, recognized

as one of the largest single contributors of silt to the Missouri and Mississippi Rivers, (and since these lands represent largely waste areas yielding only a small amount of low-grade pasturage and possibly best adapted to public control) it is proposed that funds available for erosion study in this region for the Fiscal Year 1931 shall be expended in a survey of the Bad-Lands situation. While no hope is entertained that the Bad-Lands can ever be converted into a true forest, the fact that the region, especially the deeply dissected areas, supports some growth of red cedar, lends weight to the suggestion that they may be looked upon as potential "forest areas at the headwaters of important streams."

This suggestion is based in part upon the projected activity in the Dakotas in the general study of plains planting. The two studies could be conjoined naturally and economically.

Prairie Windbreak Values

The "windbreak aspect" of prairie planting has already been mentioned. As has been the case in the Russian steppes where the common man's attitude toward trees changes with the climatic cycles, so it seems to be true in the plains region that after a series of good crop years the farmer loses sight of the importance of windbreaks to his own crops and possibly as ameliorating the climate of the region as a whole. It seems desirable to revive this subject about once in a generation and attempt to throw new light upon it. It is, therefore, proposed to make observations upon the protective effects of existing Dakota plantations along much the same lines as were followed in the windbreak study of 1908. The Bureau of Plant Industry plantations at Mandan, North Dakota, excellent demonstrations from the standpoint of tree establishment, have never been subjected to study from this angle and will doubtless form an excellent basis for such work. If possible, arrangements will be made to carry on continuous observations at this and two or three other favorable points over a series of years rather than attempting to draw conclusions from a single year's observations.

Natural Classification of Forests on the Basis of Soils

Of the forests in the region, probably not more than 10 per cent are fully stocked and express the full productive capacity of the soil. The rest has been repeatedly cut over and burned until it cannot be used as an expression of soil productivity. Yet, this is the area that will have to be replanted or converted by other means into a fully stocked forest. There is a great danger if this conversion process is not guided by a thorough understanding of the capacity of the soil to support this or that kind of tree or produce this or that yield of wood. To guide our forest practice in the region, we must have a knowledge of the soils from the standpoint of forest production, just as a farmer must understand his soils for growing his crops. This study aims to classify and group the known types of soils in the region from the standpoint of forest productivity.

It is not intended to undertake independent soil surveys but to use the large accumulation of information regarding the existing soils and to correlate this information with the forest growth. The final outcome should be twofold, (1) the preparation of a map, and (2) the prediction of the kind and growth of potential natural forests, whether they are on the ground now or not, on the basis of the different soils and their capacity to produce different types and yields of forest.

Forest Economics

To assist in adapting certain nation-wide studies to regional needs as well as to give sustained attention to a number of local economic problems, an economic unit was added to the Station January 1, 1930.

A considerable number of investigations dealing with economic phases of forestry have been carried on in the Lake States such, for instance, as the work of Sparhawk in Michigan, special studies by the Agricultural Experiment Stations in the three states, the Taxation Inquiry in Minnesota, and the Land Economic Surveys in each of the states, but there is still a large field for study.

One of the most urgent economic problems is a comprehensive and detailed Forest Survey for the entire country dealing with such matters as the amount of available timber in each region, the rate of timber depletion, the rate of growth, and the amount and trend of wood requirements. Such a national survey was started this year by the Forest Service in the Pacific Northwest. There is a need to coordinate as far as possible, all local endeavors with this nation-wide project.

Hardly less important is the need for comprehensive information on the financial feasibility of timber growing, particularly by private owners. Experience has shown that the point at which private forestry becomes profitable is not anticipated by private landowners and seized upon as it arrives. The reason is that some of the factors bearing on profits are so complex or involve simultaneous observations in such wide fields that the individual owner does not keep currently posted. The Lake States Station does not expect to be able to work out individual plans for individual owners, but should be able to help such owners materially through the collection and dissemination of the kind of information needed for scientific financial management of their properties.

The Forest Survey

The general need of a national timber survey need not be discussed at any length. It seems generally agreed that there is a very urgent need for accurate information to serve as a basis for a forest policy. It is also certain that existing information is not sufficiently up-to-date nor sufficiently accurate for such a purpose.

The local need and possible uses of the forest survey have possibly

not received as much attention as they deserve. It is, however, in local application that the survey should be of greatest ultimate value.

A survey made in southern Minnesota recently by a member of the Division of Forestry, University of Minnesota, brought out the fact that less than 20 per cent of the wood used in the industries of that district was grown within the state. Even the oak, birch, maple, and elm was largely imported. In tracing out the reasons, it was found that it was not as much an actual shortage of these woods as it was a lack of knowledge of markets and marketing methods by the woodlot owners and a lack of knowledge of local resources by the manufacturers that was to blame. This is but one instance of the possible service to local people and local industries which can come from a systematic survey of forests and forest industries.

Pulp and paper industries facing a shortage of spruce and other pulpwood, local communities seeking to maintain or expand their wood-using industries, railroads planning extensions or, in some cases, abandonment of existing branches, and the State and Federal Government in acquiring land and building up public forest units, to mention but a few, all want specific local information as to existing stands of timber, the amount and character of reproduction coming on various areas, the probable losses from fire, insects and disease, and the possibilities of supporting local industries in future years. On the basis of such a survey as was made by the state in Bayfield County, Wisconsin, a pulp company considering sustained-yield management or a minor wood-using industry considering a new location can size up the possibilities and lay its plans with some reasonable idea of future conditions. It is very probable that the development of many enterprises is being held back by lack of just this kind of information which a forest survey can develop.

On account of the limited funds available and the particular urgency for an inventory of the standing timber in the Pacific Northwest and in the South, the Forest Service will not be able to spend much money on a forest survey in the Lake States in the immediate future. Furthermore, since the total amount which the Forest Service is authorized to expend on this survey will aggregate only a little over one-half cent per acre the country over, it will be clearly impossible to make a satisfactory inventory without the cooperation of timber owners and the states. Fortunately the three Lake States in their Land Economic Surveys have embarked upon a very similar project, and it is expected that a great deal of their information can be adapted to the needs of the national survey. On the whole, it is believed that these States will be justified in giving the greatest possible attention to the forest inventory phase of their projects on the basis of immediate local needs. The Experiment Station will continue to aid these state surveys in every way possible.

Taxation

The general property tax as applies to forest lands has been

pretty thoroughly studied in the Lake States and, as a result of these studies, modified tax systems have been worked out in each state. The Pierson tax law adopted in Michigan in 1921 provides for a flat tax of 10 cents an acre on growing forest plus a 25 per cent yield tax when the timber is cut. The Wisconsin forest crop law, enacted in 1927, levies a 10 cent per acre tax with a 10 per cent yield tax later. A feature of the Wisconsin law is the provision that the state will advance 10 cents an acre to the local governments for the listed lands. The Minnesota law, as amended in 1929, levies a 5 cent per acre annual tax with 12½ per cent yield tax with no provision for state aid. Thus, it will be seen that though the same in principle, the laws in the three states are materially different in rates and notably different in application. As a matter of fact, all three laws are in an experimental stage and may be expected to go through considerable modification at least in administration during the next few years. It is important that the evolution of these forest tax laws and the study of their effect upon individual land owners, local governments, and the general forestry situation should be given at least as much expert attention as was given to their initiation. For the present it is proposed merely to follow developments closely in each state and compare results.

Statistical Service

There are two general needs in the field of statistics. The first is to round up and harmonize as far as possible the vast amount of information which has been published concerning the forests and forest industries of the Lake States. It is not likely that much can be immediately added to the accuracy of previous quotations of forest areas, standing timber, growth rate, and the like, but it is believed worth while to assemble these for critical study and in some cases it may seem justifiable to modify or bring them down to date. In any event, the collection and systematic arrangement of this material is believed worth while.

The second need is the local adaptation of nation-wide statistics such, for instance, as are periodically collected by the Forest Service and other government bureaus and by some of the trade associations. The Station will be able to sift out material of greatest local significance and in many instances will be able to give local interpretations to general figures. In a similar way, information of considerable significance to the region can be sifted out from state and local reports and fitted into the general picture.

Forest Finance

A great deal of work has been done on the subject of financial feasibility of growing timber. Most of this, however, has been of a very general nature, somewhat comparable to the development of normal yield tables in forest mensuration. The broad possibilities have been worked out, and it must be admitted that the general picture has not been particularly encouraging to private owners in this general region.

There is need now for more particularlized study in the Lake States. We are gaining a great deal of information about the growth rate of various forest types in natural and planted stands, and of the productivity of various soils. The states are gradually accumulating a record of the actual distribution of these soils and forest types as well as of the size classes and the degree of stocking in the natural stands on the ground. The more important carrying charges, taxes and fire protection have been more or less stabilized. Several private companies and doubtless a considerable number of farmers are actually engaged in growing timber as a business. On the basis of this new and accumulating information and experience, it should be possible to get down to cases at least to an extent that will be of help to timber owners, pulp companies, and farmers who are contemplating a start in forest management.

The Land Use Problem

Sparhawk's study in northern Michigan has shown clearly the adverse effects of improper land use -- transient industries, discontinued transportation, loss of taxes, and deserted homes. Studies of particular counties in Wisconsin made by the Agricultural Experiment Station indicate a rather alarming situation in that state resulting from forest destruction. Tax delinquency and its related ills are indicated by the Tax Inquiry in Minnesota.

The problem now is not as much to discover or demonstrate the ill effect of improper land use as it is to discover ways and means of reconstructing the communities and reestablishing taxable values. This is not altogether a problem for foresters, but it is pretty generally agreed that forestry will play a large part in the reconstruction. The point is, that there is need for constructive action, and constructive action should be based upon facts. Probably the most urgent need in this connection is a county-by-county economic survey which will bring out such facts as tax delinquency, ownership of land and purpose of ownership, profits and trends in agriculture, farm abandonment, recreational development, local industrial development, cost of roads, schools and local government and all of the financial aspects of the tax situation. From such local studies, intelligent and constructive action can develop. Such a study is being carried on in each of the three states at the present time as a part of the Land Economic Survey.

Concurrent with and subsequent to these detailed local surveys, there is need for keeping in close touch with the general trends in agricultural development, tax delinquency, public and private forestry endeavors, and the like, information which is constantly needed in guiding the forestry movement in the Lake States along sensible lines. Through its many contacts in the three states, it is expected that this Station can be of considerable service in this latter connection.

Forest Biological Studies

In January, 1930, the Bureau of Biological Survey detailed a biologist to the Station to conduct studies in wild life problems relating to the forests. This work is still in a formative stage, but some plans for definite investigations have already been made. Experiments will be started this year to determine points of ecological and distributional significance concerning the faunas of the various areas of distinctive forest types. Such studies must, of necessity, extend over a considerable length of time before significant data can be amassed, but it is expected that this research will lead to a more adequate and comprehensive understanding of the relationships existing between the forests themselves and the wild life that they shelter.

Probably of more immediate interest and value, though certainly of no more importance than the longer-term studies, will be the thorough investigations to be made of such injurious species to the forests as the snowshoe rabbit and the porcupine. The damage done by these two animals alone ranks second in importance only to the destruction by fires, and scientific studies for the purpose of learning how to alleviate it are considered to be well worth while. Other specific problems that will be worked on concern the importance of rodents and seed-eating birds to seed-destruction and seed dispersal. It is expected that much of the work will be carried out on experimental plots already established by the Station for the study of other forest problems.

The Snowshoe Rabbit

Snowshoe rabbit damage is confined practically to a very few weeks each year, during that period known as the "spring break-up," which usually extends from the latter part of March through the first two weeks in April. During the dead of winter the snow is too deep and too light to allow the rabbits to travel far, and they stay confined to their warrens in the heavy swamps and brush patches where they find plenty of cover and a modicum of food. At this season they live mainly on the bark and persistent fruits of such shrubs as the alder and the dogwood, and they devour aspen bark eagerly when they can reach the tender tips of the lateral branches, as in a felled tree. When such foods are lacking, they do not disdain the needles of adult evergreens and have even been found chewing the tips of the lower branches of 15-year-old Norway pine.

When the snow begins to melt with the warming days, and the cool nights form a crust upon which they can travel, they leave their sheltering swamps and forage far abroad for food to supplement their limited hiemal diet. As the snow melts, the first green things to be exposed are the tops of the young conifers, six inches to two feet in height. The rabbits greatly relish the tender terminal shoots, especially those of the white pine and Norway pine, and hop along the rows of the plantations, nipping off the luscious buds from the top of each seedling. The result is, at best, a stunted, warped and crooked seedling, and persistent

nippings will eventually kill them. It takes from five to twenty years for a seedling to grow tall enough so that its top is out of reach of the rabbits.

While much damage is done throughout the forests to natural reproduction, it is most concentrated and critical in those areas that have been replanted by the Forest Service. All of the planting now being done on the Chippewa and Superior National Forests is by means of seedling trees which are set out in barren areas it is wished to restock, or in areas covered by inferior stands such as aspen, which it is wished to convert to a more valuable forest type. Large sums are invested in the planting, much of which is damaged in the rabbit-infested regions. Though it is difficult to estimate in dollars and cents the amount of damage the rabbits do yearly, the loss is very great, and one that should be prevented if possible.

When the rabbits occur in normal numbers, as at present, and are not swarming in droves in every locality, the damage is slight, and causes little worry. It is most keenly felt during the peaks of the rabbit population which occur once every six to ten years. The last "peak" was in 1924 and 1925, and we may expect the next one in 1932 or 1933. It is essential that control measures be taken before that time in an effort to lessen the rabbit damage, especially in the areas where planting is in progress.

It is equally essential that further investigations be carried on into the distribution, life history, and ecology of the snowshoe rabbit in order that control measures may be taken in a more efficient and effective manner. Investigators from several institutions are studying the rabbit from different angles. Some are working on the periodicity itself and are trying to find out its exact mechanics. Others are conducting experiments on various phases of the disease, Tularemia, which has been proven to be of prime importance in the rabbit cycles. It is hoped that researches now being planned here will produce new facts about the life history and distribution of the species, especially as the habits and actions of individual rabbits are concerned, a virtually untouched field. It is felt that observations on animals marked so as to individualize them may furnish us additional data concerning their movements under natural conditions in the wild state, all of which will prove of great assistance to the forest protection measures that must be taken against them.

The Porcupine

The porcupine damage to the forest areas is confined almost entirely to the large evergreens, and is done mainly during the winter. In the summer their food consists of economically unimportant herbs and shrubs, and but little damage to valuable species is noted when there is no snow on the ground. While the porcupines neither hibernate nor "yard up" during the winter in the strict sense of these terms, the heavy snow

restricts their movements greatly, and, finding a suitable location with plenty of cover and food, they tend to stay in this spot all winter. Like the rabbits, they prefer to be near swampy areas, and most of the damage they do is noted in the immediate vicinity of heavily wooded bogs. They spend much of their time holed up in dens in the earth, under rocks, stumps, or uprooted trees, coming forth only to feed. Their wintering ground is most often in a thick clump of white pine or jack pine. They climb to the tops of the trees and keep themselves alive by chewing off the bark and eating the tender cambium there. This girdling blights the top at once, stops growth, and eventually kills the whole tree. They favor the white pine above all other trees, with the jack pine coming a close second. They also attack Norway pine, balsam, maple, spruce, tamarack, and hemlock, in about the order named.

The animals are not very numerous in the Lake States, so the damage they do is not considerable. As far as the loss of the trees themselves goes, it is negligible, not more than $4 or $5 stumpage per tree, and considering that the porcupines are not too common, certainly the monetary value of the trees they destroy is far outweighed by their presence in the forests as an interesting member of the local fauna.

Where they do the most harm, however, is in killing off the white pines in the aspen areas, as in the Cutfoot Sioux Ranger District of the Chippewa National Forest. There are some 16,000 acres of aspen here on one area, the soil of which is highly suitable for white pine. Throughout the area are scattered a few large white pines which it is hoped will act as seed trees and eventually convert the present stand into one of the more valuable species. The porcupines in this region do not touch the aspen, but confine their attentions entirely to the white pine, killing off the potential reseeders of the area. Though it is difficult to estimate their value by monetary standards, such trees are worth considerably more than just their mere stumpage. It is evident that the porcupine depredations in such an area should be prevented.

Though it would not be difficult to accomplish, it would be a shame to consider extirpating the porcupines completely from this region. They are an integral part of the north woods, and would be sadly missed for their color value. There is much ancient sentiment attached to them as being the starving man's friend, as they are practically the only animals in the woods that can be killed readily without a gun. This old sentiment is gradually dying out, and here in Minnesota the species is no longer protected by law. Inasmuch as they furnish the main food of the fisher and, to some extent, of the lynx, the presence of porcupines is desirable as sustenance of these valuable and interesting fur bearers.

As a whole, the problem is not a serious one, except in such local areas as have been mentioned. It is not felt that the situation at present warrants any heavy expenditures for control measures, though further and more detailed studies of the habits of the animal should be made.

The Smaller Animals

Of tremendous economic importance to the forests are the several species of squirrels, mice, and shrews that inhabit them. Their only harmful attributes worth taking into consideration at present are their tendencies to delay both natural and artificial reproduction by feeding on the seeds of valuable forest trees. Their beneficial activities, in general, are the accidental distributing and planting of seeds and the destruction of noxious insects.

Paralleling the reseeding experiments to be established by the Forest Service, a set of experimental plots will be started this summer to determine the effect of small mammals and birds on artificial seeding over areas covering the various forest types. This will entail a study of the distribution of the different mammalian species numerically in correlation to the type of plant cover, and a thorough investigation into the feeding habits of the mammals in each of the several environments. It is hoped that these studies will eventually lead to a detailed summation of the relation of the vertebrates to natural reproduction.

It has been shown by the activities of the Bureau of Entomology, that mammals play an important role in the destruction of the larch sawfly, and that an average of 60 per cent of all the sawfly larvae that manage to spin cocoons are consumed by mice and shrews. Investigations will be carried on to determine not only the as yet unknown species responsible for the good work, but also the complete ecology of the animals concerned, in order that their activities may be encouraged.

PERMANENT SAMPLE PLOTS - January 1, 1930

Total number - 84
Total area - 69.05 acres
(Arranged by lines of work)

Serial plot number	Location	Object	Acreage	Establishment	Examination	Remeasurement
		Management of Northern Hardwoods				
1-3 Dukes	1 mile E of Dukes, Michigan	Methods of cutting (Mc-2)	6.00	June 1927	June each year	June 1932
6-8 Dukes	1½ miles E of Dukes	(Mc-2)	1.50	Oct. 1927	Oct. each year	Oct. 1932
9-13 Dukes	1 mile E or Dukes	(Mc-2)	6.00	Aug. 1928	Aug. each year	Aug. 1933
14-15 Dukes	1½ miles E of Dukes	(Mc-2)	0.71	May 1928	Oct. each year	Oct. each year
16-17 Dukes	1 mile E of Dukes	(Mc-2)	3.00	May 1929	May each year	May 1934
18-21 Dukes	1½ miles E of Dukes	(Mc-2)	1.88	May 1929	Oct. each year	Oct. each year
22-25 Dukes	1 mile E of Dukes	(Mc-2)	5.00	Nov. 1929	May each year	May 1935
		Management of Pine Forests				
1-4 Chippewa	3 miles SE of Bena, Minnesota	Methods of cutting Norway-white pine stands (Mc-1)	1.47	June 1923	May each year	May 1931
9-12 Chippewa	2 miles S of Cass Lake, Minnesota	Methods of cutting jack pine (Mc-106)	4.00	May 1926	May each year	May 1931
18-21 Chippewa	5 miles NW of Cut-foot Ranger Station	Thinning Norway-jack pine pole stands (Mt-1)	2.00	Sept. 1927	May each year	Sept. 1932

Serial plot number	Location	Object	Acreage	Establishment	Examination	Remeasurement
22-25 Chippewa	3 miles NW of Cutfoot Ranger Station	Thinning Norway pine reproduction (Mt-1)	0.54	Sept. 1927	May each year	Sept. 1932
26-30 Chippewa	7 miles E of Cass Lake, Minnesota	Thinning jack pine sapling stands. (Mt-106)	5.00	Aug. 1929	May each year	Aug. 1934
1-4 Superior	1 mile N of Baird Ranger Station	Methods of cutting jack pine (Mc-106)	2.00	Nov. 1926	June each year	June 1932
17-19 Superior	6 miles S of Ely, Minnesota	Methods of cutting jack pine (Mc-106)	6.00	Sept. 1929	Sept. each year	Sept. 1934
1 Huron	NW of Silver Creek Ranger Station	Natural reproduction Norway pine (Mr-2)	3.60 (98 secs.)	1917	None further	1933
		Management of Swamp Forests				
13-17 Chippewa	7 miles SE of Bena	Effect of water level upon forest growth (M-1)	2.00	May 1927	May each year	May 1932
4-5 Dukes	2 miles E of Dukes	M-1	1.90	Oct. 1927	Oct. each year	Oct. 1932
		Conversion of Inferior Stands into More Valuable Forests				
5-8 Chippewa	2 miles SE of Pike Bay, Minnesota	Possibilities of converting aspen to conifers-natural reproduction, seed spotting and planting under different densities of crown (M-371)	0.90	May 1926	May each year	May 1931
31-36 Chippewa	6 miles E of Cass Lake		2.80	Aug. 1929	May each year	Aug. 1934
37-39* Chippewa	1/3 mile S of Pike Bay		0.75	Oct. 1929	Throughout each summer	Oct. 1934

*Also listed under Type Studies.

Serial plot number	Location	Object	Acreage	Establishment	Examination	Remeasurement
5-7 Superior	7½ miles N of Grand Marais	Planting conifers under open aspen (M-371)	3.00	Sept. 1928	Sept. each year	
8-10 Superior	8 miles S of Baird Ranger Station	Planting conifers under dense aspen, partially removed (M-371)	3.00	Sept. 1928	Sept. each year	Sept. 1923
11-12 Superior	6 miles N of Cramer	Planting conifers under dense brush (M-371)	2.00	Sept. 1928	Sept. each year	
13-15 Superior	Four-mile Ranger Station	Conversion of decadent birch, natural seeding vs. planting (M-371)	3.00	June and Sept. 1928	Sept. each year	June 1933
14-15* Dukes	1½ miles E of Dukes	White pine plant under aspen (M-371)				
18-21* Dukes	1½ miles E of Dukes	Conifers planted in an open stand of young maple (M-371)				
		Reforestation Studies				
1 Cloquet	Near fire tower (See also conversion studies)	Seed production Norway pine (Fs-105(c))	1.00	Sept. 1929	Aug. each year	Sept. 1934
		Tree Breeding (Forest Genetics)				
2* Dukes	1 mile E of Dukes	To encourage seed production by bird's-eye maple (Bb-332)				
		Type Studies				
37-39** Chippewa	1/3 mile S of Pike Bay	To study the effects of physical factors on establishment and early growth of coniferous reproduction (T-4)				

* Also listed under "Management of Northern Hardwoods."
** Also listed under Conversion of Inferior Stands.

Serial plot number	Location	Object	Acreage	Establishment	Examination	Remeasurement
		Volume, Growth, and Yield Studies				
1-3 6-8 9-13 16-17 22-25 Dukes*		Growth of virgin stands and of stands after cutting				
		Forest Soil Management				
		Practically all permanent sample plots bear on the problem of soil management.				
		Forest Biological Studies				
5-8 37-39 Chippewa**		Effect of rabbits upon natural and artificial reproduction.				

* Also listed under Management of Northern Hardwoods.
** Also listed under conversion of Inferior Stands.

SUMMARY

What the Station has Done in 1929

1. The analysis of forest fires in Michigan was completed. The report will appear as a bulletin of the Michigan Conservation Commission.

2. Plans were completed for the establishment of a Forest Fire Research Station near Roscommon, Michigan, in cooperation with the Conservation Commission of that state.

3. Over 32 acres of virgin forest at the Station's Upper Peninsula branch near Dukes were logged to demonstrate new methods of cutting.

4. On 7 acres of cut-over land on the experimental forest near Dukes, improvement cuttings were made, blank spaces planted, and young stands put under more favorable growing conditions.

5. An intensive soil survey was made for the experimental forest area, involving the digging of 130 soil profiles. Soil maps were made and correlated with existing stands; 12 monoliths of the most typical genetic soil types were obtained and put in the Station's collection.

6. The seed-control station was installed at University Farm and began operation in the fall of 1929. To date about 280 germination tests have been run, 50 of which were of commercial seed samples.

7. A method of pretreating white pine seed was discovered which makes practicable sowing in the spring as well as in the fall.

8. Volume and yield tables for second-growth white pine have been constructed and a report prepared on its growth, yield, and commercial possibilities in that state. This is to appear as a bulletin of the Wisconsin Agricultural Experiment Station.

9. A manuscript on the availability, properties, and utilization of aspen has been written in cooperation with the Forest Products Laboratory and the Division of Forestry, University of Minnesota, to be published as bulletin of the Minnesota Agricultural Station.

10. The erosion study carried on in cooperation with the University of Wisconsin in the non-glaciated part (southwestern corner) of that state was completed. The results will be published as a research bulletin of the Wisconsin Agricultural Experiment Station this spring.

11. As a result of a joint study between the Station and the Division of Soils, University of Minnesota on leaf litter, a paper was prepared on the quantity and nutrient contents of pine leaf litter by Dr. F. J. Alway and Raphael Zon. This will appear in an early issue of the Journal of Forestry.

12. Twenty-two new permanent sample plots were established and counts made on the reproduction strips of 13 of these and 23 others.

13. All plot data were worked up and assembled in mimeographed form as a guide to the Station's permanent sample plots. This has been distributed among the forest officers of the region.

14. A forest economic unit was established with the assignment of a forest economist to the Station.

15. A forest biologist under the U. S. Bureau of the Biological Survey was assigned to the Station.

16. North Dakota and South Dakota were added to the territory covered by the Station's activities.

17. Twelve technical notes were prepared and distributed.

18. Eight research bulletins were issued and about fifteen articles were published in various journals and magazines.

19. Twenty-two addresses and lectures were given by members of the staff.

20. Seven thousand letters were handled during the year.

What the Station is Working On

1. Fire Hazard: Factors contributing to fire hazard and the modifying effect of different methods of cutting and slash disposal; observations conducted at branch field stations.

2. Forest Fire Damage: Physical damage to existing stands and the effect of fire on soil and growth. Michigan, Wisconsin, and Minnesota.

3. Selective Logging in Northern Hardwoods: Practicability of partial versus clear cutting; the results of various degrees of partial cutting; the cost of logging under present and selective cutting systems. Northeastern Wisconsin and the Upper Peninsula of Michigan.

4. Woodlot Management: With special emphasis upon the demonstration of proper methods of handling woodlots. In cooperation with the Wisconsin Forest Extension Specialist, southern Wisconsin.

5. Methods of Cutting Jack Pine to Promote Its Conversion to More Valuable Conifers: Chippewa and Superior National Forests.

6. Thinning Young Norway Pine Stands. Chippewa National Forest.

7. Thinning Jack Pine Stands. Chippewa National Forest.

8. Natural Reproduction of Norway Pine on the Michigan Sand Plains. Huron National Forest.

9. Methods of Cutting Norway Pine Stands. Chippewa National Forest.

10. Effect of Water Level in Swamps upon Forest Growth. Upper Peninsula of Michigan and Chippewa National Forest.

11. Conversion of Inferior Stands into More Valuable Forests: Natural and Artificial Regeneration. Chippewa and Superior National Forests and the Upper Peninsula of Michigan.

12. Effect of Oak Cover on Pine Plantations. In cooperation with the University of Michigan. Lower Peninsula of Michigan.

13. Reforestation: Improved reforestation methods; seed storage; pretreatment of white pine seed; grading of seed.

14. Seed Production of Norway Pine: In cooperation with the Cloquet Forest Experiment Station. Cloquet Experimental Forest.

15. Tree Breeding: Effect of seed source on suitability of trees for planting; differentiation of growth zones based on climatic factors; planting of bird's-eye maple; forms of Scotch pine.

16. Fundamental Laws Underlying the Development of Stands.

17. Causes of Soil Erosion and its Control by Forest Planting and Engineering Works.

New Investigations Planned for 1930

1. New studies will be initiated at the Roscommon Forest Fire Research Station on:

a. The relation between fires and weather as a means of predicting fire weather.
b. The use of chemicals in fire suppression and control.
c. Fire breaks and fire lines, and
d. Fire-fighting methods and equipment.

The work will be carried on jointly with the Michigan Conservation Commission.

2. A new branch station will be established in Wisconsin for the purpose of investigating the problems encountered in growing raw material for the pulp and paper industry. The University of Wisconsin and the Wisconsin Conservation Commission will cooperate with the Station in this field.